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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1369

Rev.ed. follows

BRIDGE GRAFTING

THERE ARE FEW FRUIT GROWERS who have not suffered loss because of the girdling of their trees by mice, rabbits, or other rodents. Pear growers are familiar with the encroachments made by blight when that disease attacks the trunks of the trees and rapidly spreads until it completely girdles them. Girdling by this means is just as certain to kill the trees as is girdling by the removal of the bark. Where injury of this character occurs it is usually possible to save the trees with comparatively little expense by bridge grafting, as described in this bulletin.

While the various steps in the operation must be done with care and precision and with regard to details, there is no reason why anyone who is sufficiently skillful in the use of his hands to fit together closely two pieces of wood should not be successful in making bridge grafts. No one who has a girdled tree need hesitate to employ bridge grafting in saving it because of the intricacies or difficulties of making the graft.

This bulletin is a revision of and supersedes Farmers' Bulletin 710, Bridge Grafting of Fruit Trees, by W. F. Fletcher, formerly Scientific Assistant, Office of Horticultural and Pomological Investigations. A portion of that bulletin is incorporated in the present one.

Washington, D. C. Issued November, 1923

BRIDGE GRAFTING.

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INTRODUCTION.

NUMEROUS INQUIRIES are received at the Department of Agriculture every spring in regard to the treatment of fruit trees, especially apple trees, that have been girdled or otherwise injured during the winter by mice and rabbits. While there are various ways in which slight injuries of this character may be treated, if any attention seems advisable, wounds which girdle or nearly girdle the trunk require the application of rather active measures if the tree is to be saved. In such cases bridge grafting is the method of treatment commonly employed; in fact, it is about the only remedy that can be recommended.

A bridge graft is made by using scions or small limbs to connect the two portions of the bark of a stock which have been separated by an injury; in other words, the injured area is "bridged" by a scion or scions, the ends of which unite with the uninjured parts above and below the wound in such a manner that a connection between the tissues is established.

RANGE OF USEFULNESS OF BRIDGE GRAFTING.

Bridge grafting may be used successfully on almost any kind of fruit tree that admits of being readily propagated by grafting. In practice there is occasion to resort to it much more frequently with the apple than with any other fruit, but pear trees are often treated, at least in some sections. No reason is apparent why the method should not be successful on plums and cherries. Peaches graft less readily than the other trees mentioned, and there may be some question as to the usefulness of the method in the case of this fruit. Bridge grafting is seldom used on shade or other ornamental trees, but with some kinds it would probably prove successful in overcoming certain types of injuries.

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The injuries which can be overcome or lessened by bridge grafting are always local in character and do not of themselves at the time they occur seriously affect the health and vigor of the tree either above or below the injured area. Such injuries are usually either mechanical or pathological in character.

MECHANICAL INJURIES.

Mechanical injuries which may be remedied by bridge grafting are usually inflicted in one of three ways: By animals that feed upon the bark and tender wood, by insects that burrow through the growing layer of bark and wood, or by implements used in the tillage of the orchard, usually the result of the carelessness of workmen.

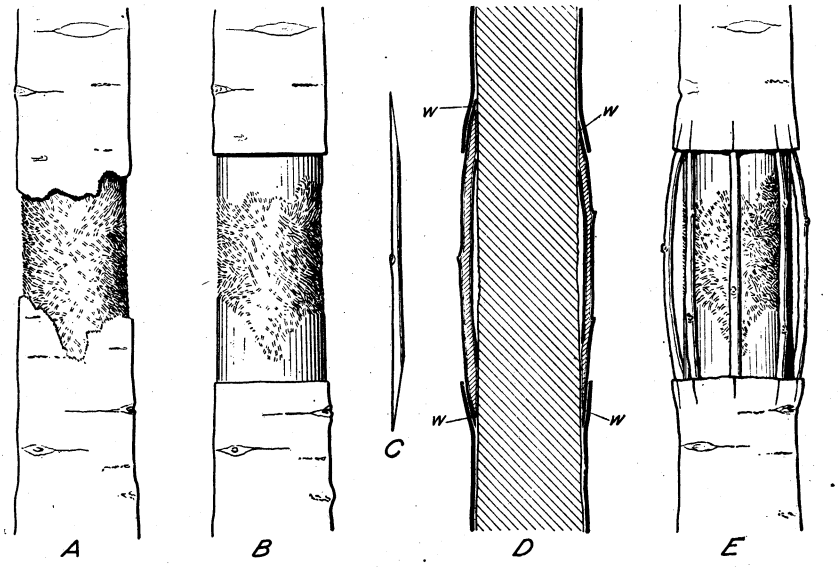

FIG. 1.—Details of bridge grafting: *A*, The trunk of a tree girdled by mice; *B*, the wound cleansed and the bark along the margins trimmed back to healthy, growing tissue; *C*, a scion with beveled ends ready for insertion; *D*, longitudinal section of the trunk with scions in place, showing their insertion under the bark of the trunk (*w*); *E*, scions in place ready for waxing.

The animals liable to do the most damage by girdling are the common meadow mouse, pine mouse, pocket gopher, and rabbit—the cottontail in the States east of the Great Plains and the jack rabbit westward from the range of the cottontail to the Pacific Ocean.

Most of the injury caused by these animals is done during the dormant period, when other plants on which they feed are scarce. Rabbits, however, occasionally gnaw young trees quite early in the fall, and mice, especially meadow mice, may work at almost any time under the shelter of vegetation that has been allowed to accumulate about the base of trees.

Mice and gophers work usually near the surface of the ground or snow, though sometimes the injury may extend for a considerable distance both above and below the surface, especially the latter. Some species of mice and also gophers may eat the small roots as

well as the bark. Young trees are more likely to be attacked than older ones, but sometimes trees of mature age are seriously injured by these animals.

Where the injury is below the ground it is likely to remain unnoticed until it is revealed in the spring or early summer by the evident weakness of the tree after growth starts. If an injury is not suspected until the season is well advanced, the tree may be too far gone when it is discovered to be saved by any method of treatment.

FIG. 2.—A girdled apple tree, with the rough, irregular edges of the bark bordering the wound trimmed back evenly preparatory to bridging.

Rabbits feed mostly at night and, although they work entirely above ground, may do a great deal of damage, sometimes to the extent of stripping practically all the bark from the body of the tree. However, in the case of young trees, if even a small portion of the inner bark between the upper and lower edges of the wound is left, they often make a good recovery if soil is mounded over the wound, but it should be done promptly after the injury occurs, to prevent the drying out of the tissues. Before mounding, however, it is well to disinfect the wounded area with bluestone solution and cover it with liquid grafting wax.

Borers are the only insects which are likely to girdle the body or trunk of a tree.

PATHOLOGICAL INJURIES.

Local injuries may be caused by various diseases, of which pear-blight, or "body blight" as it has been called, is the most common. The trunks of pear trees are not infrequently completely girdled and killed by this disease. If taken in time, however, it may be possible to save the tree by cutting away the diseased bark, thoroughly disinfecting the wounded area, and then bridge-grafting it. A coal tar-creosote tree paint made by mixing these two substances

in proportions of one-third to one-fourth of the latter and two-thirds to three-fourths of the former may be used for disinfecting and protecting wounded areas, but it is best not to apply it directly to exposed cambium where new growth in the healing of the wound is desired.

Relatively large areas of bark may also be killed by what is commonly called sun scald, as well as by other troubles that are pathological or mechanical in their nature. The losses from such injuries may often be greatly reduced by resorting to the method of treatment here described.

FIG. 3.—An apple tree 3½ inches in diameter girdled by rabbits, with the scions bridging the girdled area in place. The time required for preparing the tree and completing the work of bridge grafting was about 1 hour and 20 minutes.

DETAILED INSTRUCTIONS FOR BRIDGE GRAFTING.

The important steps in bridge grafting are shown in diagram form in Figure 1. In preparing the wound to receive the grafts the injured parts should be thoroughly cleansed and all dead tissue cut away. The irregular edges of the bark (fig. 1, *A*) at the upper and lower margins of the wound should be cut back evenly, as shown in Figure 1, *B*.

It is important that the scions should be a little longer than the space that is to be bridged. This is in order that the middle portion of the scions when put in position shall arch slightly over the central part of the wound. This is illustrated in Figure 1, *D*, where a longitudinal section of a bridge graft is shown.

Before being placed in position the scions are beveled at each end, both beveled surfaces being on the same side of the scion, as shown in Figure 1, *C*. This beveling should be done with a long, sloping cut, so that the wedge-shaped ends thus formed will be relatively thin, to permit their being thrust well under the bark without danger of separating it unduly from the cambium at the points of insertion. Reference to Figure 1, *D*, illustrates this feature.

Bridge grafting is done in early spring about the time the trees are starting into growth, the same as in cleft grafting for the purpose of top-working. It does not matter if the trees to be bridge grafted have started slightly, but it is of great importance that the scions be perfectly dormant. The chances of success are materially decreased if the buds on the scions have started appreciably. As previously stated, the fact that a tree has been girdled below the ground may not be known until it shows signs of failure after growth starts. If dormant scions were available at that time it might still be possible in some cases to save the tree by bridge grafting, though earlier action is strongly advisable.

FIG. 4.—The same tree shown in Figure 2, with the scions bridging the girdled area in place.

It is often necessary to secure the scions some time in advance of their use, in order to have them in a dormant condition when needed, storing them meanwhile where they will not dry out and where it is cool enough to keep them dormant. If placed on top of the ice in an ice house and properly covered they will keep well. If no better place is available, burying them in the ground on the north side of a building or other shaded place and covering deep enough so they will not be quickly affected by the warming up of the soil in early spring may suffice. In the latter case the scions should be wrapped in something that will prevent the soil from coming in direct contact with them; otherwise enough grit will adhere to quickly dull the edge of the knife used in trimming the scions. For this purpose a very sharp knife is needed. And, further, a board should be placed over the scions before covering them with soil, or some other means adopted to protect them against excessive moisture in case of long-continued and heavy rains while they remain buried.

The best growth to use for bridging is a water sprout or the well-ripened terminal growth of the previous season. Scions one-fourth

to three-eighths of an inch in diameter are the easiest to use. If too large, it is difficult to spring them into place; if too small, it is hard to secure the ends in position.

No special tools are required. The outfit needed consists of a spade and trowel for use in removing the earth from the base of the tree and from the roots near the base where the injury is underground; a heavy pruning knife with which to trim and smooth the rough edges of the wound; a keen, thin-bladed knife for preparing the scions; an oilstone for use in keeping the knives sharp; a pair of hand pruning shears; some small five-eighth-inch brads for holding the ends of the scions closely in position and a light hammer for driving them; and a 2-quart can for holding the grafting wax, if liquid wax is used, with a 1-inch brush for applying it. If hard grafting wax is used, a little tallow for the hands to prevent the wax from sticking to them will be desirable.

FIG. 5.—The example of bridge grafting shown in Figures 2 and 4, after the scions had made one season's growth. One scion had developed a root where it had been covered with soil mounded up about the base of the tree.

PREPARATION OF GIRDLED TREES FOR BRIDGING.

The details of preparing the trees vary with the extent and nature of the injury. If the girdled area is entirely above ground, as when done by rabbits, it is necessary only to trim back evenly the bark at the edges of the wound, as shown in Figure 2. If the injury has been caused by mice and they have worked on the roots, it will be necessary to uncover them as far back as the wounds extend in order to reveal the extent of the injury and to afford freedom of action in the repair work.

MAKING THE UNIONS.

In fitting the ends of the scions to the trees the essential requirement is that the cambium layer of the scions be brought into very close contact with the cambium layer of the tree and held in that position until they grow together. There are several ways by which this close contact may be brought about, as described later.

APPLICATION OF BRIDGE-GRAFTING METHODS IN ACTUAL PRACTICE.

Some specific examples of bridge grafting and its results, together with an account of some of the details, as applied by the writer in several typical cases near Washington, D. C., will serve to indicate the effectiveness of this method of saving girdled trees when rightly employed. The accompanying illustrations give the substance of the details.

The scions used in the work were cut in January, when the trees were pruned, and held in cold storage at a temperature of 40° F. Those about the size of a lead pencil were found to be the most satisfactory for use.

Figure 3 shows a tree 3½ inches in diameter that was girdled by rabbits, about as shown by the tree in Figure 2. The edges of the wound were trimmed evenly as indicated, and then the scions bridging the girdled area were put in place as follows: The ends of the scions were beveled by a sloping cut about 1½ inches long (fig. 1, *C*), the scions being 2 to 3 inches longer than the width of the wounded area to be bridged.

FIG. 6.—The example of bridging shown in Figures 2, 4, and 5, after the scions had made two seasons' growth.

In putting the scions in place, cuts were made through the bark extending vertically for about 1½ inches from the edge of the wound and at each place where the end of a scion was to be inserted. This is suggested in Figure 1, *E*, and is also shown in Figure 3, where the scions are in place.

After the vertical cuts were made, the bark was carefully lifted just enough to admit the beveled end of a scion. A twig about the size of the scion and with the end trimmed like the beveled ends of a scion was found to be useful for lifting the bark. The upper end

of a scion was then slipped into its position (fig. 3); while holding it in place the lower end was inserted in a similar manner by springing the scion out in the middle. It was necessary to tack the ends down to make them fit closely enough against the tree, the small five-eighth-inch brads, previously mentioned, being used for this purpose. The completed work is shown in Figure 3, except for waxing over the edges of the bark and the ends of the scions. This should be done very thoroughly, in order to exclude all air from these parts,

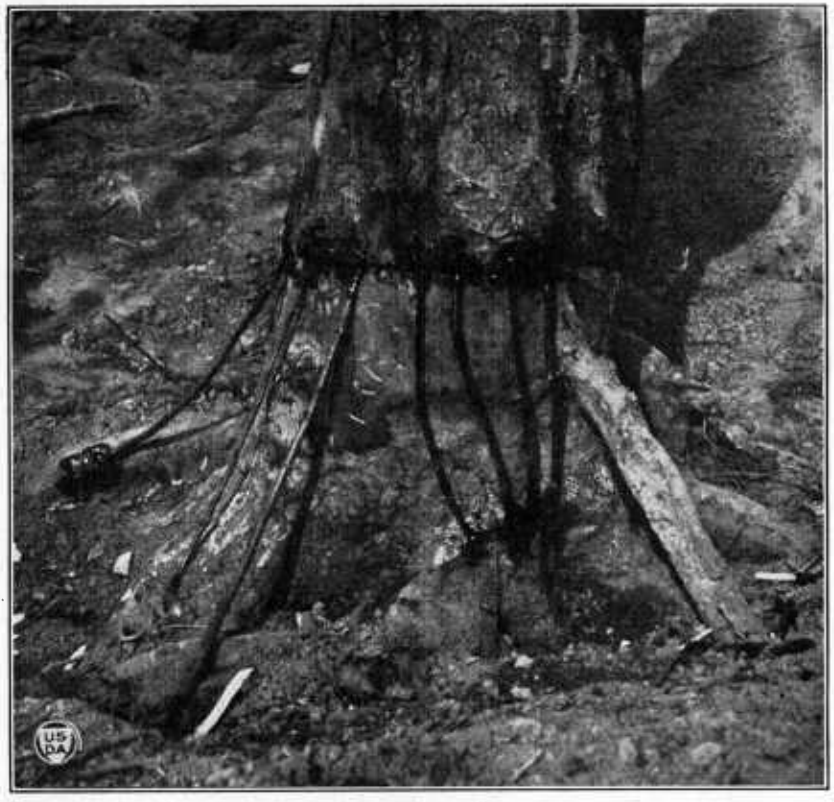

FIG. 7.—A Fallawater apple tree 11½ inches in diameter girdled by mice, the wounded area including the base of some of the larger roots, here shown with the bridging completed, including the waxing, and the tree ready to be banked up with soil. This completed work required 8½ hours' time.

thus preventing the drying out of the tissues which would otherwise occur.

The time required to bridge-graft the tree shown in Figure 3 was about 1 hour and 20 minutes.

The job shown in Figures 2 and 4 (completed in the latter, except the waxing) was done in an hour in early April, and the grafts as they appeared the following December are shown in Figure 5. After the bridging was completed, the base of the tree was mounded with soil. One of the scions, as seen in Figure 5, developed a root. The same tree is again shown in Figure 6 after the scions had made two seasons' growth.

In the case of the tree shown in Figure 7 the conditions were quite different from those just described. The tree was $11\frac{1}{2}$ inches in diameter and the wounded area extended well down on all the large roots. The scions were put in position in the same manner as in the previous case, Figure 7 showing the work after the wax had been applied. It required eight and one-half hours to repair this tree. Figure 8 shows the scions in December following the grafting, which was done the preceding April.

FIG. 8.—The tree shown in Figure 7, after the scions had made one season's growth.

Another way of fitting the scions to the tree is preferable when the wound extends far down on the roots where the bark does not slip readily or the position is such that it is difficult to push the ends of the scions under the bark. By this method each end of the scion is pared off on one side for a distance of 2 inches or more, the cut extending about half way through the scion, or nearly to the pith and parallel with it, instead of being beveled as previously described, thus leaving a flat surface at each end.

Instead of slitting the bark at the edge of the wound and slipping the ends of the scions under, a small piece of bark is removed, of such size that the end of the scion, previously flattened by trimming, can be fitted into it very closely, thus bringing the cambium of the scion, exposed at the edges of the trimmed flattened surface, into

contact with that of the tree where the bark was removed to receive the scion. After being put in position the ends of the scion are held fast by nailing with small brads. Figure 9 shows a tree treated in this manner, with the wax applied to the ends of the scions and the edge of the wound. The details are more clearly shown in Figures 10 and 11, the latter showing the work completed and the wax applied. In the case of Figure 9, mice had gnawed the bark from the roots to such an extent that the scions could not be attached readily by the first method described, but the conditions were successfully met by the second method. Figure 12 shows the growth made by the scions in one season. The scions used were nearly 3 feet long,

FIG. 9.—A Green Newtown apple tree about 1 foot in diameter girdled by mice from the surface of the ground and the bark gnawed from the roots to such an extent that scions about 3 feet long were required to bridge the wound. This job consumed 8½ hours.

the wound extending from the surface of the ground, where the trunk was girdled, for a considerable distance on the roots. Figure 13 is the same case after the scions had made two seasons' growth. The time required to treat this tree was eight and one-half hours.

This method of fitting the scions is applicable to old trees on which the bark is too firm and stiff to admit of the ready use of the method first described.

A form of approach grafting can be used to save a tree with roots so badly injured that scions can not be readily attached to them. This method requires the use of small seedling or nursery trees 3 to 6 feet in height, planted at the base of and close to the trunk of the injured tree, the exact point of planting being determined by the character of the top and the position of the limbs or other parts of

the small trees. Figure 14 shows an apple tree near the base of which two small trees have been planted with a view to approach grafting.

FIG. 10.—Bridge grafting by inlaying the ends of the scions, in contrast to pushing them under the bark.

The small tree at the right has a branched top. This is an advantage, because it provides for two unions of this tree with the trunk of the injured tree.

Figure 15 shows the same tree as Figure 14 after the grafting has been done. The sides of the branches toward the trunk of the injured tree (in case of the small tree at the left, it was the body of the tree itself) were carefully shaved off to expose the cambium and provide

FIG. 11.—The tree shown in Figure 10, with the work completed and the ends of the scions and edges of the wound fully waxed.

a flattened surface for making the contact and were so shaped that they would fit closely into matrices made in the trunk by removing narrow sections of the bark just sufficient in size to receive the branches after they had been properly trimmed off, as above described. The branches after being put in place on the trunk of the

tree were held there by small brads. The tops of the small trees above the points of union are left until after the parts grow together and are then cut off just above the union. Figure 16 was handled in like manner, so far as the use of small trees is concerned. However, the tops of the small trees were fitted to the trunk of the injured tree by use of the second method described. The sides of the small trees next to the trunk were pared off for a distance of several inches and were then brought into contact with the cambium of the trunk by cutting out narrow sections of the bark at the proper places and carefully fitting in (inlaying) the tops of the small trees, which were nailed in place, thereby holding in intimate contact the exposed cambium of the adjacent parts. The details are made clear by reference to Figure 16, which shows the work completed, except the waxing.

FIG. 12.—The tree shown in Figure 9, after the scions had made one season's growth.

Figure 17 shows the same tree as in Figure 16 after one season's growth of the union had been made; Figure 18, after two seasons' growth.

Substantially the same method is used to save pear trees where the trunk and larger roots have been girdled by blight.

SPACING THE SCIONS.

In the work described the scions were usually spaced from 2 to 4 inches apart. The closer they are together the quicker the wound will heal over. However, it is frequently difficult to get suitable points of union for close spacing. When the scions were slipped under the bark a spacing of 2 inches was found to be as close as they could be placed without raising the bark between the ends of the

scions at the edge of the wound. If the bark was slightly started at these points, it was found it could be tacked down and any adverse results avoided thereby.

APPLYING GRAFTING WAX.

Careful attention must be given to the waxing of the parts of the wound where healing and growth are to take place. The ends of

FIG. 13.—The tree shown in Figures 9 and 12, after the scions had made two seasons' growth.

the scions and the exposed edges of the bark on the trunk must be thoroughly covered as a final operation in the grafting.

The waxed areas ought to be examined frequently until after the parts have united and the healing is well advanced. Any separation of the wax from parts that need protection must be repaired and more wax applied if needed. The growth of the scions is likely to force openings in the wax; such places should have prompt attention. Where the wounded area extends below the ground it may be covered with soil and the tree mounded up somewhat, making rewaxing unnecessary. In several of the cases described in the foregoing pages the wounded area and grafts were completely covered with soil.

Either hard or liquid (semiliquid) wax may be used, as preferred. The latter can be applied somewhat more quickly than the hard wax, but either will give the necessary protection if properly followed up. If used during cold weather, some means of heating a liquid wax is commonly necessary in order to apply it readily.

FIG. 14.—A girdled apple tree with small seedling trees planted at its base ready to be joined by approach grafting.

MAKING GRAFTING WAX.

A good hand wax may be made of the following ingredients: Resin, 4 parts; beeswax, 2 parts; tallow or linseed oil, 1 part by weight. If harder wax is needed, 5 parts of resin and 2½ of beeswax may be used with 1 part of tallow.

FIG. 15.—The tree shown in Figure 14, with the grafting completed except applying wax thoroughly to all cut surfaces that are exposed to the air. The tops of the small trees above the points of contact with the trunk of the girdled tree are left until after the parts have grown together, when they are cut off close to and immediately above the union.

The resin and beeswax should be finely broken up and melted together with the tallow. Then the liquid should be poured into a vessel of cold water, and as soon as it becomes hard enough to handle it should be taken out, pulled, and worked until it becomes tough and has the color of very light colored manila paper. When the wax is applied by hand the hands should be well greased, tallow being the best material for this purpose.

FIG. 16.—An Early Joe apple tree 10 or 12 inches in diameter, badly girdled below the surface of the ground by mice, repaired by inarching or approach grafting the tops of small trees planted about the base of the tree. The work is here shown completed except applying wax thoroughly to all cut surfaces exposed to the air.

Waxed string may be prepared by putting a ball of No. 18 knitting cotton into a kettle of melted grafting wax. In five minutes it will be thoroughly saturated, after which it will remain in condition for use indefinitely. Waxed grafting cloth may be prepared in a similar manner; that is, by placing narrow strips of cotton cloth in melted grafting wax.

Another wax recommended by a correspondent of this department is made of 1 pound of beeswax, 3 pounds of resin, and 1 pint of pure

raw linseed oil. The directions for making are: Melt in a double-boiler until thoroughly fused, pour into water to cool, and then pull until the mass has the color of good light molasses candy. The melting and fusing in a hot-water bath and pulling make the difference between good wax and poor. This is said to produce a wax that is easy to work in cold weather and will not run in warm weather.

A soft wax to be applied with a brush may be made by thoroughly melting and fusing together 3 pounds of resin, ½ pound of beeswax, and ½ pint of pure linseed oil. When used in cool weather it may be necessary to warm this wax in order to apply it readily.

FIG. 17.—The tree shown in Figure 16, after one season's growth of the graft unions.

SAFEGUARDS.

In recent years fruit growers in many sections of the country have suffered heavily because of the extent to which mice have girdled their trees. Since most of the injury has been below the surface of the ground, it has frequently not been detected until the trees have shown evidence of failing some time after growth was renewed in the spring. However, in many instances fruit growers have become fully aware of the danger and have taken pains to determine early in the spring whether mice had been working on their trees during the winter. The method of saving girdled trees through bridge

grafting has become rather widely understood in recent years, and it has been applied successfully in thousands of instances in different parts of the country. In some of the States the experiment station and extension workers in horticulture and pomology have devoted considerable attention to this problem.

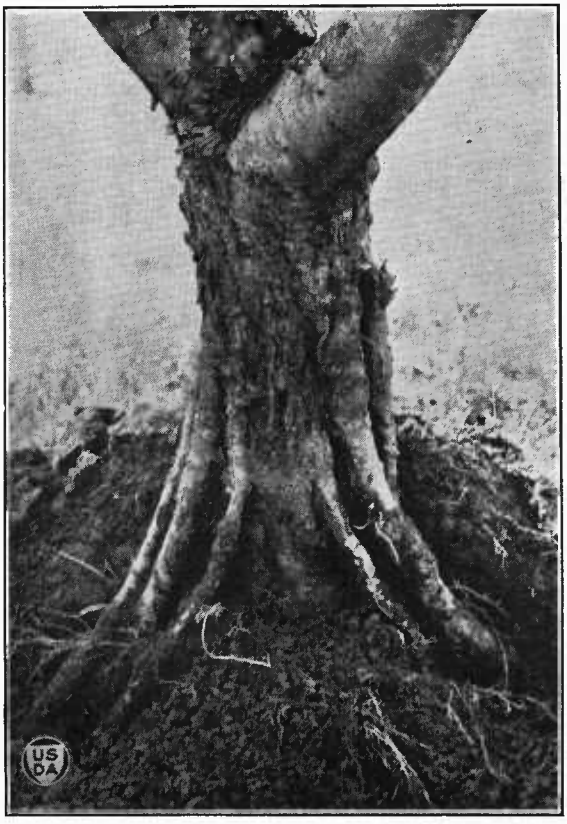

FIG. 18.—The tree shown in Figures 16 and 17, after growth of the graft unions for two seasons.

Although the cost of doing this type of repair work is small compared with the value of the trees that may be saved, it is wise to adopt preventive measures as far as possible. Such methods have been given considerable attention. Information concerning them may be obtained from the United States Department of Agriculture and from many of the State agricultural experiment stations. Farmers' Bulletin 1397, Mouse Control in Field and Orchard, is of interest in this connection.

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October 4, 1923.

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